This four-year assessment, combined with lack of Illinois River Watershed waters on the state 303(d) list, demonstrates that dissolved oxygen is not a particular concern in the Illinois River Watershed.

6.3.2 Bacteria Indicator Levels in the Illinois River Watershed Are Comparable to Other Systems within Oklahoma

Bacteria groups that may be monitored as indicators of risk for water-transmitted illness from fecal contamination to humans are reviewed in Section 5.2 of this report. River locations throughout the state of Oklahoma are routinely tested for all three standard indicator bacteria groups. Here, results throughout Oklahoma were compared to determine the relative degree of indicator bacteria contamination within the Illinois River Watershed to statewide levels of contamination.

6.3.2.1 Data sources and analysis methods for Oklahoma bacterial indicator comparison

Oklahoma indicator bacteria data were compiled from the following databases: the USGS, the OWRB, the Oklahoma Conservation Commission, USEPA STORET, and the Oklahoma Attorney General. Only data results in units of CFU/100 ml or MPN/100 ml were considered, and values below the detection limit were set equal to the detection limit for analysis. Sample IDs for each USGS/Oklahoma sampling location were standardized so that all available data could be combined for each location (OK station ID formats varied among data sources and the USGS and OK use different ID series for the same stations).

According to USEPA guidance, to indicate the typical impairment level of a water body, one uses the geometric mean of bacteria counts in samples collected over the duration of the swimming season (USEPA 1986, 2004). This is the period during which full-body immersion resulting in oral disease transmission is most likely to occur. Therefore, in this analysis, only samples collected from May through September, the likely extent of the swimming season in Oklahoma and the usual sampling period for the USGS and Oklahoma, were included. Samples in each swimming season were combined to calculate the seasonal geometric mean for that year and location. Duplicates and other cases of multiple samples per day were averaged to get one value per date prior to geometric mean analysis.

The geometric means calculated here are not directly comparable to water quality standards because a lower cutoff for frequency of sampling was used. The point of this analysis is to compare statewide results to each other, not to a standard. (USEPA guidance indicates bacteria samples should be collected at a frequency of five per 30 days for public swimming locations, but the Oklahoma data were typically collected less frequently, usually 1-2 times per month). Geometric means were calculated only in cases where there were at least five sampling dates per season for that location (a frequency of at least one per month).

Results were analyzed for the 2003, 2004, and 2006 swimming seasons. There was insufficient sampling in 2005, 2007, and 2008 to conduct statewide comparisons for those years. Earlier years were not considered.

6.3.2.2 Results of Oklahoma bacterial indicator comparison

Enterococci geometric means for May through September throughout Oklahoma are shown for 2003, 2004, and 2006 in Figures 6-5a, 6-5b, and 6-5c respectively. The Illinois River Watershed is shaded grey in all figures, and results are color coded with respect to how the geometric mean compares to the USEPA water quality criteria threshold (WQT) of 33/100 ml (CFU/100 ml or MPN/100 ml) for enterococci. In 2003, no site in Oklahoma had a seasonal value for enterococci below the WQT, and values in excess of 5 times (5x) the WQT occurred frequently throughout the state. However, the Illinois River Watershed contained a lower concentration of enterococci (some values in the 1-2x WQT range) than was typical for the state. In 2004, enterococci values were somewhat lower than 2003, but the majority of sampled locations both within and outside of the Illinois River Watershed were still in excess of 2x the WQT. In 2006, while there were far more enterococci results < 2x the WQT, some values > 5x the WQT still occurred, however values did not exceed 5x the WQT in the Illinois River Watershed, and did not exceed 1x the WQT in Lake Tenkiller.

Escherichia coli geometric means for May through September in Oklahoma are shown for 2003, 2004, and 2006 in Figures 6-5d, 6-5e, and 6-5f respectively. Results are color coded with respect to the 126/100ml WQT for *E. coli*. In contrast to enterococci, *E. coli* values > 1x the WQT were relatively rare in all three years. More values > 1x the WQT occurred in 2003 and 2006, than in 2004, including two within the Illinois River Watershed in 2003. There were no *E. coli* geometric mean values > 1x the WQT in the Illinois River Watershed in 2004 or 2006.

Fecal coliform geometric means for May through September in Oklahoma are shown for 2003, 2004, and 2006 in Figures 6-5g, 6-5h, and 6-5i respectively, with results color coded with respect to the 200/100ml WQT for fecal coliform. In keeping with enterococci and *E. coli* results, geometric mean values for fecal coliform within the Illinois River Watershed were similar to, or less than, the rest of Oklahoma.

In summary, this data analysis found the magnitude of seasonal indicator bacteria geometric mean values in the Illinois River Watershed were typical of values throughout the entire state of Oklahoma. Thus, there is no evidence that local poultry litter application contributes to exceptional levels of indicator bacteria, and by association risk of waterborne illness, within the Illinois River Watershed.

SECTION 7
WATER QUALITY IS IMPROVING IN THE ILLINOIS RIVER AND LAKE TENKILLER

7.1 SUMMARY OF DETAILED FINDINGS

- The water quality within the Illinois River Watershed is getting better.
- The improving water quality is evidence that poultry litter application is not a dominant cause of water quality impairment.
- Water quality improvements correlate with changes in WWTP loadings.

7.2 THE IMPROVING WATER QUALITY IS EVIDENCE THAT POULTRY LITTER APPLICATION IS NOT A DOMINANT CAUSE OF WATER QUALITY IMPAIRMENT

7.2.1 Water Quality Improving Despite Increasing Poultry Population

The long-term record of phosphorus concentrations in the Illinois River at Tahlequah shows an apparent reduction beginning in about 2003. This reduction was explored by analyzing the 2004 to 2008 data separately from the pre-2004 data. Figure 7-1 shows the relation between stream flow and phosphorus concentrations for both periods. Reductions are evident for both base flow and runoff flow conditions, although the comparisons for the runoff conditions are hampered by the limited data at high flows. The average concentrations during base flow and runoff flow conditions for the two periods are shown in Figure 7-2. Under base flow, the average total phosphorus concentration drops from about 0.11 mg/L in the 1997 to 2003 period to about 0.07 mg/L in the 2004-2008 period. A similar drop occurs for high flow, but because the uncertainty bars around the means overlap, the difference is likely not statistically significant.

The chlorophyll-a record is much less definitive than the phosphorus record, but, as discussed in Section 4.3, there appears to be a decline in maximum chlorophyll-a level in the riverine section of Lake Tenkiller.

7.2.2 Water Quality Improvements Correlate with Changes in WWTP Loadings

Dr. Jarman, on behalf of the defendants, estimated the annual phosphorus loads from the WWTPs in the Illinois River Watershed (Jarman 2008). He calculated that between 1997 and 2003, the annual load averaged about 60,000 kg (range between about 48,000 and 68,000 kg), whereas between 2004 and 2007 it averaged about 37,000 kg (range between about 31,000 and 42,000 kg). The lower load beginning in 2004 reflects treatment upgrades. The WWTP load drops by about 40%. The drop in average base flow phosphorus concentration mirrors the WWTP load drop, also declining by about 40% (0.11 mg/L to 0.07 mg/L). Section 2.9 of this report showed that the WWTP load accounts for the phosphorus in the river under base flow, so the correspondence of the drops in WWTP load and in river base flow total phosphorus concentrations is not surprising.

SECTION 8
THE WATER QUALITY MODELING CONDUCTED BY THE PLANTIFFS' CONSULTANTS IS FLAWED AND PROVIDES NO MEANS TO ASSESS PHOSPHORUS IMPACTS

8.1 SUMMARY OF DETAILED FINDINGS

- The Plaintiffs' lake model produces erroneous conclusions because it is flawed and inaccurate.
- The Plaintiffs' lake model misrepresents how nutrients (principally phosphorus) entering the lake affect water quality within the lake.
- As a result of its flaws, the model predicts benefits from reducing poultry litter application that will not occur.

8.2 THE LAKE MODEL MISREPRESENTS HOW NUTRIENTS (PRINCIPALLY PHOSPHORUS) ENTERING THE LAKE AFFECT WATER QUALITY WITHIN THE LAKE

Dr. Scott Wells developed a water quality model of Lake Tenkiller with the intent of predicting the changes in in-lake concentrations of algae, phosphorus and dissolved oxygen resulting from changes in phosphorus loading to the lake. A basic test of this model is its ability to reproduce observed nutrient and chlorophyll-a concentrations and trends. The model fails this test.

The top panel of Figure 8-1 shows the average surface chlorophyll-a concentrations at the four primary lake sampling stations as measured by the Plaintiffs and as predicted by the model for the same time period (May-November 2005; March-September 2006; and April-August 2007). It is clear from the graph that the model predicts chlorophyll-a concentrations that fail to come close to matching what is going on in the lake. Whereas the data show an upstream to downstream decline from average values of 20 µg/L at LK-04 to 10 µg/L at LK-03 to 8 µg/L at

LK-02 and LK-01, the model inexplicably predicts a rise in chlorophyll-a from 20 µg/L at LK-04 to 35 µg/L at LK-03 and then a drop to about 13 µg/L at LK-02 and LK-01.

The bottom panel of Figure 8-1 presents the same type of model to data comparison for surface SRP. The data show that the SRP at LK-04, which is most representative of the SRP entering the lake, is on average about 37 µg/L. By the time the water reaches LK-03, nearly all of this SRP is absent. The average SRP level at the lower three lake stations is consistently only 2-3 µg/L; levels that typically limit algal growth. The loss of SPR between LK-04 and LK-03 is not accompanied by an increase in chlorophyll-a, so it is not likely explained by algal uptake. The best explanation is that the inflowing water seen at LK-04 dove to the hypolimnion before LK-03. The substantial evidence for this phenomenon is discussed in Section 4.2.

The model predicts SRP concentrations that are too high at all of the stations. It predicts a decline from LK-04 to LK-03 that appears to be associated with the increase in chlorophyll-a that it predicts between these stations. At LK-02 and LK-01, it predicts concentrations that are 7 to 10 times too high. It is likely that the model fails to correctly simulate the diving of the inflowing water and keeps phosphorus in the surface waters. This is clearly an inaccurate representation of the dynamics occurring in the lake and indicates a major flaw on the Lake Tenkiller model.

8.3 AS A RESULT OF ITS FLAWS, THE LAKE MODEL PREDICTS BENEFITS THAT WILL NOT OCCUR FROM REDUCING POULTRY LITTER APPLICATION

Dr. Wells uses the water quality model to predict the water quality changes anticipated to occur in Lake Tenkiller as a result of future changes to lake phosphorus loadings. The model cannot do this with any reliability because it does not correctly account for the fate of phosphorus that enters the lake. Because it over-predicts the availability of phosphorus for algal growth, it will predict that algal levels in the lake are highly sensitive to changes in phosphorus loading. In reality, algal levels in the lacustrine sections of the lake (LK-02 and LK-01) are likely somewhat insensitive to loading changes because of the movement of much of the phosphorus into the hypolimnion. Drs. Cook and Welsh note this fact in their report for the Plantiffs (Cook and Welsh 2008). On page 22 of their report they state:

> *It is this deposition of river-borne materials, and the formation of higher density water masses that flow well beneath surface waters (epilimnion) that protects the surface waters (epilimnion) of lower stations (LK-02 and LK-01) from some of the direct impacts of polluted river inflows. This means that the degree of eutrophication (trophic state) at LK-01 and LK-02 will be less than LK-03 and LK-04 because the eutrophying materials dive below the warmer surface waters.*

Dr. Well's model is wrong because it does not properly account for the fate of the incoming phosphorus and it cannot be relied on to evaluate how water quality in the lake might change if phosphorus loads change.

SECTION 9
A REVIEW OF FIELD PROCEDURES BY THE PLAINTIFFS' CONSULTANTS

Camp, Dresser, and McKee (CDM) and others conducted field investigations between 2005 and 2008 in support of the State of Oklahoma's litigation against the Poultry Industry. The field investigations were conducted under 22 SOPs developed by CDM (Brown 2008). These SOPs describe sample collection and handling procedures for water, sediment, soil, litter, and aquatic biological assessments for a number of different programs. Based on my experience designing and conducting field investigations, I believe that the shortage of detail in the SOPs may have compromised data quality.

As defined in USEPA's Guidance for Preparing SOPs (USEPA 2007c), SOPs are developed to document a routine or repetitive activity that is performed by employees. SOPs are an integral part of a successful quality system. They provide information necessary to perform a job properly and consistently in order to achieve pre-determined specifications for data quality. SOPs should present adequate detail so that a person who has a basic understanding of the task to be performed but lacks specific experience or knowledge of the work to be performed can successfully perform the procedure when unsupervised.

SOPs for environmental field investigations (as well as most other purposes) are normally developed prior to initiating field activities and are designed to satisfy specific, detailed data quality objectives (DQOs). The Olsen (2008) states on page 3-2 that the DQO process only applies to situations where a decision is to be made between two clear alternatives, and therefore, the full DQO process was not required for this project. The USEPA guidance that defines the DQO process (USEPA 2006) states the following:

> *The DQO Process is a series of logical steps that guides managers or staff to a plan for the resource-effective acquisition of environmental data. It is both flexible and iterative, and applies to both decision-making (e.g., compliance/non-compliance with a standard) and estimation (e.g., ascertaining the mean concentration level of a contaminant). The DQO Process is used to establish*

performance and acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. Use of the DQO Process leads to efficient and effective expenditure of resources; consensus on the type, quality, and quantity of data needed to meet the project goal; and the full documentation of actions taken during the development of the project.

As stated in the second sentence of this quotation, USEPA regards the DQO process to be applicable to decision-making situations and to projects where the development of estimates, such as identifying contaminant levels, is an objective. The objectives of each sampling program (Olsen 2008, Section 2) include developing an estimate of the nature and extent of contamination; therefore, the USEPA would require that the full DQO process be applied to this project. The State of Oklahoma (ODEQ 2006, Section 1.6) acknowledges the necessity of DQOs by strongly recommending that the laboratory is included in early stages of project planning so they can provide data which meet project DQOs. It further recommends that the project manager distribute the work plan, sampling plan, and Quality Assurance Project Plan (QAPP) to the laboratory for review and comment.

The DQO process is typically documented in a QAPP (USEPA 2001b, reissued May 2006). USEPA and many other public and private entities consider QAPPs critical to the collection of data of quality sufficient to make decisions and perform evaluations. A QAPP defines the quality assurance/quality control (QA/QC) procedures to be followed for both field and laboratory activities and also specifies the requirements for assessing data quality, typically including both data verification and data validation. The lack of a comprehensive QAPP complicates assessing whether the quantity and quality of data collected are adequate to satisfy the goals of this project.

Preparation of a formal QAPP, including implementation of the full DQO process, may have resulted in selecting other approaches, fewer revisions to SOPs and higher quality data. Often, the SOPs that were developed present the procedures to be followed only in a general manner. Sometimes they were revised after the field work was completed to reflect the procedures that were actually followed (pp. 36-37 of Darren Brown deposition). Additionally, some sample collection and handling activities were left to the discretion of the field staff who may not have had the appropriate site knowledge or background to make such decisions in the field. This ambiguity can result in inconsistency in data collection procedures among field staff, as different personnel may interpret the SOPs in different ways.

The four major concerns relating to the lack of detail contained in the SOPs are discussed below. They include QA/QC samples, hold times, documentation, and cross-referencing between SOPs.

- The number and type of QA/QC samples were loosely defined. The SOPs typically included statements like "control samples may include…". The number and type of each QA/QC sample to be collected should be defined for each parameter in the SOP, otherwise field staff either must make assumptions or solicit supervision. An example of an appropriate specific requirement for QA/QC samples would be to require the collection of a set of QA/QC samples, including a matrix spike, matrix spike duplicate, blind duplicate and equipment rinse blank at the rate of one per 20 environmental samples, with the specific analyses that samples will be submitted for listed. QA/QC requirements often vary from parameter to parameter.
- Timing requirements were generally undefined. The SOPs did not specify timing requirements for sample collection, handling/processing, or shipment. The amount of time that elapsed between sample collection and laboratory analysis is critical for some parameters (e.g., 6 hours for bacteria analysis per USEPA Code of Federal Regulation (CFR) guidelines, Title 140, Part 136 [http://ecfr.gpoaccess.gov]). The SOPs did not specify the timeframe within which samples had to be analyzed in order to produce quality data. An example of a sample that exceeded typical holding time requirements involves the sampling of chlorophyll-a in Lake Tenkiller. On May 17, 2005, LK-03-1 was collected at 14:05. According to the chain of custody, the samples including LK-03-1 were relinquished on May 18 at 19:30 and received by the laboratory on May 19 at 10:00. The Analytical Report produced by Aquatic Biological Sciences containing this sample (SDG 08708) notes that LK-03-1 was analyzed for corrected and uncorrected

chlorophyll-a on May 19 at 4:30:00 PM. A typical holding time for chlorophyll-a is 48 hours. In this case, the time between the sampling event and the analysis exceeds a typical holding time. Again, field staff would either have to make assumptions or solicit supervision regarding the timing of sample collection, handling/processing (e.g., filtration, preservation) and shipping to the appropriate laboratory. In many cases, the field staff did solicit supervision, as noted in the field books. During a June 2, 2005 sampling event, a member of the field staff "Phoned Ron discussing sampling protocols for chlorophyll-a." Dr. Olsen's report (2008; p. 3-15) acknowledges that meeting sample holding times was problematic, resulting in concerns regarding data quality.

- Requirements for field documentation of sampling activities were very general, often specifying that "all aspects of sample collection and handling as well as visual observations will be documented…". Requirements like these force the field staff to make an interpretation of what "all aspects" means, and can result in considerable variability in the information recorded by different field staff. Specific requirements in the SOP, such as defining exactly what information is needed is typically included to improve consistency between field staff. For example, minimum requirements specifically described in an SOP might include:
  - program name;
  - date;
  - time;
  - location;
  - coordinates;
  - weather conditions;
  - sampling method;
  - water depth;
  - sample processing performed in the field;
  - analytical requirements and specific containers used for each;
  - QA/QC samples collected; and
  - observations.

  An example of where more detail would be recommended is keeping samples on ice. Even when the same field staff is on site, notes regarding keeping samples on ice are not consistent. For instance, during a river and lake sampling event on June 1-2, 2005 (see 2005-06_Lake_Sampling_Book_1.pdf), there is no mention of keeping the samples on ice on June 1, while on June 2 it is noted that a member of the field staff was sent to "get more ice to keep samples."

- The SOPs were not appropriately cross referenced. For example, chain of custody, sample packing, and sample shipping procedures were not consistently described in the SOPs; and while these procedures were presented in SOP 9-1, individual SOPs typically did not reference this SOP. Another example is when samples required filtration; the sample collection SOPs did not reference the SOP that included the procedures for sample filtration.

Specific examples of procedures that were not well defined in some of the SOPs are presented in the following subsections.

9.1 SOP 1-1 (TENKILLER FERRY RESERVOIR SAMPLING)

In SOP 1-1, the type of sample (discrete or composite) to be collected, or specific depths from which samples or aliquots were to be collected are not provided. In Section 3.3, the SOP states "collect a discrete water sample from the required depth as described in previous sections of this document"; however, specific criteria for sampling depths are not provided. In Section 4.0, the SOP states that "Either at the end of the week or periodically throughout the sampling, samples will be packed and shipped in coolers to one of several analytical laboratories…". Specific directions for shipping samples in a manner so that holding times could be met are not provided. This is particularly critical for parameters with a short holding time (e.g., bacteria). The decontamination procedures are not appropriate for the collection of samples for metals analyses. Typical decontamination procedures for equipment used to collect metals samples includes rinsing with weak acid to remove residual metals. Additionally, the SOP did not specify the type or number of QA/QC samples to be collected, and did not reference other SOPs that provide information regarding sample handling, or chain of custody procedures.

9.2 SOP 2-1 (AUTOMATED HIGH FLOW SAMPLING)

Section 3 of SOP 2-1 describes a process for selecting sampling locations. This process is very general; different individuals could select different sampling locations. Sampling locations should be predetermined and documented in a work plan, not left to the discretion of field staff the SOP should focus on the operation of the sampling equipment and sample collection. The location of the automated sampler intake tubing can be critical to sample integrity. For example, if the sampler intake tubing is located close to the stream bed, sediment can be introduced into the sample. If the intake is located in a stagnant pool instead of a freely flowing portion of the stream, data quality can be affected. Section 4 of this SOP provides only general guidance on the location of the automated sampler intake tubing.

The SOP did not clearly identify a timeframe for sample collection, shipping, filtration, and analysis. This information is critical for samples that are to be analyzed for parameters having short holding times (e.g., bacteria) and for parameters that require preservation upon collection (e.g., metals). As automated samples are composites of aliquots collected over a period of time, holding time is even more critical. The SOP does not specify the allowable elapsed time between any of the following steps:

- initiation of sample collection;
- collection of the final aliquot;
- arrival of field staff to pick up the aliquots;
- shipping aliquots to laboratories;
- combining the aliquots into composites and transfer to laboratory containers; and
- shipping laboratory containers to laboratories for analysis.

The example program in the SOP would result in a total sampling time of 52 hours; allowing unpreserved aliquots to sit in the autosamplers at ambient temperature until retrieved by field staff. The aliquots were then shipped overnight to a laboratory for compositing and filtration, placement in laboratory containers and preserved. The composite samples were then shipped overnight to an analytical laboratory. This process would result in an elapsed time of approximately four days before analysis could be performed compromising the Plaintiffs' ability to defend the integrity of the produced data where analytical hold times were exceeded, most notably bacteria. Additionally, the SOP did not specify the type or number of QA/QC samples to be collected, did not specify sample labeling requirements, and did not reference other SOPs that provide information regarding sample handling, chain of custody procedures, or compositing/filtration procedures. Documentation requirements were general, which may have allowed variability in the information recorded by different field staff. Lack of clear and specific directions compromises the Plaintiffs' ability to defend the integrity of the produced data.

9.3 SOP 2-2 (HIGH FLOW SAMPLE COMPOSITING AND FILTERING)

It is not clear from this SOP (Section 4) how the compositing scheme was developed for each sample or who was responsible for doing it, which may have resulted in inconsistent approaches among locations. As discussed for SOP 2-1, there was no timeframe specified for how long samples could be stored prior to filtration, preservation, or shipment. Additionally, the SOP did not specify the type or number of QA/QC samples to be collected, did not specify sample labeling requirements, and did not reference other SOPs that provide information regarding sample handling, or chain of custody procedures. Documentation requirements were general, which may have allowed variability in the information recorded by different field staff. Lack of clear and specific directions compromises the Plaintiffs' ability to defend the integrity of the produced data.

9.4 SOP 3-1 (SPRING SAMPLING)

In SOP 3-1, the type of sample (discrete or composite), and the sample collection method (surface grab or pump) appears to be left to the discretion of the field staff. Logic for making these decisions is not provided, which may have resulted in inconsistent approaches among locations. The procedures for the collection of samples for metals analyses (Section 3) did not exclude the use of a metal sampling container, nor were the decontamination procedures (which were not specified in earlier versions of the SOP) appropriate for the collection of samples for metals analyses. Typical decontamination procedures for equipment used to collect metals samples includes rinsing with weak acid to remove residual metals. Additionally, the SOP did not specify the type or number of QA/QC samples to be collected, and did not reference other SOPs that provide information regarding sample handling, or chain of custody procedures. As outlined in Churchill (2008) revisions to the SOP between version 2 and version 3 (dated January 19, 2006 and February 5, 2007, respectively) resulted in less stringent wording regarding sampling location and QA/QC sample requirements which introduced ambiguity and could result in inconsistent implementation of the SOP. Lack of clear and specific directions compromises the Plaintiffs' ability to defend the integrity of the produced data.

9.5 SOP 4-1 (SEDIMENT SAMPLING IN STREAMS AND SMALL IMPOUNDMENTS)

In SOP 4-1, the sample collection method specifies use of a polycarbonate tube; ponar dredges and scoops are listed as contingency methods. No logic is provided for determining when contingency methods should be used; selection of the sampling method appears to be left to the discretion of the field staff. This approach may have resulted in inconsistent decision making by field staff. Additionally, the SOP did not specify the type or number of QA/QC samples to be collected, and did not reference other SOPs that provide information regarding sample handling, or chain of custody procedures. Documentation requirements were general, which may have allowed variability in the information recorded by different field staff. Lack of clear and specific directions compromises the Plaintiffs' ability to defend the integrity of the produced data.

9.6 SOP 4-2 (SEDIMENT SAMPLING OF TENKILLER FERRY RESERVOIR)

This SOP describes sediment sampling procedures; however, it does not provide criteria for determining whether an acceptable sample has been collected. For example, it is typical for sediment sampling SOPs to specify target sample recoveries for core samples, and to provide guidance on what an acceptable recovery in relation to core penetration. A deep penetration with a poor recovery can indicate inappropriate coring techniques have been used, or that additional attempts to collect representative cores should be made. Additionally, a minimum sample volume is not specified, which could result in the collection of an insufficient amount of sediment for analysis. Section 3.2 of the SOP discusses sectioning of the cores, but provides no details on what the length of the sections should be. Additionally, the SOP did not specify the type or number of QA/QC samples to be collected, and did not reference other SOPs that provide information regarding sample handling, or chain of custody procedures. Documentation requirements were general, which may have allowed variability in the information recorded by different field staff. Lack of clear and specific directions compromises the Plaintiffs' ability to defend the integrity of the produced data.

9.7 SOP 6-1 (WATER SAMPLING)

In SOP 6-1, the type of sample (discrete or composite), and the sample collection method (surface grab or pump) appears to be left to the discretion of the field staff. Logic for making these decisions is not provided, which may have resulted in inconsistent approaches among locations. The procedures for the collection of samples for metals analyses did not exclude the use of a metal sampling container, nor were the decontamination procedures appropriate for the collection of samples for metals analyses. Typical decontamination procedures for equipment used to collect metals samples include rinsing with weak acid to remove residual metals. Additionally, the SOP did not specify the type or number of QA/QC samples to be collected, and did not reference other SOPs that provide information regarding sample handling, or chain of custody procedures. The provided filtration procedures were general, and it is unclear whether the procedures followed were consistent with those presented in SOP 12-1 (General Water Preparation and Filtering - EOF, Springs, and Groundwater). Lack of clear and specific directions compromises the Plaintiffs' ability to defend the integrity of the produced data

9.8 SOP 8-1 (WATER QUALITY METERS)

This SOP provides guidance on calibration of field water quality meters prior to use. While calibration is critical to the collection of high quality data, proper care and use of the instrumentation in the field is also required. This SOP does not provide instruction on deploying the instrumentation and collecting data; instead, it refers the reader to other SOPs for this information. The information in other SOPs (e.g., SOP 6-1) pertaining to use of water quality meters is too general. The probes used on these instruments are sensitive and must be handled carefully to maintain calibration. The technique used to deploy the probe is also important. Examples of improper deployment include not placing the probe in a representative location (in moving water versus stagnant water), allowing the probe to come in contact with sediment, or not taking into consideration the depth of the water and the potential for stratified layers to exist. This type of guidance is generally absent in the SOPs. Lack of clear and specific directions compromises the Plaintiffs' ability to defend the integrity of the produced data

9.9 SOP 10-1 (EDGE OF FIELD SAMPLING)

The logic for selecting sampling locations in this SOP is general and requires judgment on the part of field staff in the determining representative sampling locations for field run-off. The SOP states in Section 4, "Improper sample collection can involve using contaminated equipment, excessive disturbance of the sample site, and sampling in an obviously unrepresentative location. Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems." It is unclear how following proper decontamination procedures and minimizing disturbance of the sample site could eliminate sampling in an unrepresentative location.

The sequencing and timing of sample collection, shipment to a staging area or CDM laboratory in Denver for sample processing/filtration/preservation, and final shipment to analytical laboratories is not well defined; it is unclear how much time was allowed to elapse between actual sample collection and laboratory analysis. A reference to other SOPs that provide information regarding sample handling, filtration, or chain of custody procedures was not provided. The procedures for the collection of samples for metals analyses did not exclude the use of a metal sampling container, nor were the decontamination procedures appropriate for the collection of samples for metals analyses. Typical decontamination procedures for equipment used to collect metals samples include rinsing with weak acid to remove residual metals. Additionally, the type and number of QA/QC samples to be collected was not specific. Lack of clear and specific directions compromises the Plaintiffs' ability to defend the integrity of the produced data

9.10 SOP 12-1 (GENERAL WATER PREPARATION AND FILTERING)

Although not referred to in other SOPs, this SOP appears to have been used for many of the field sampling activities. It does not specify how much time could elapse between sample collection, filtration, preservation, or shipment. Several key analytes are time sensitive in nature (e.g., bacteria), and ideally would be submitted for analysis immediately after collection. Again, not specifying rigid sample handling procedures and holding times may have resulted in exceeding normal analytical holding times compromising the Plaintiffs' ability to defend the integrity of the produced data.

SECTION 10
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FIGURES

Quantitative Environmental Analysis, LLC
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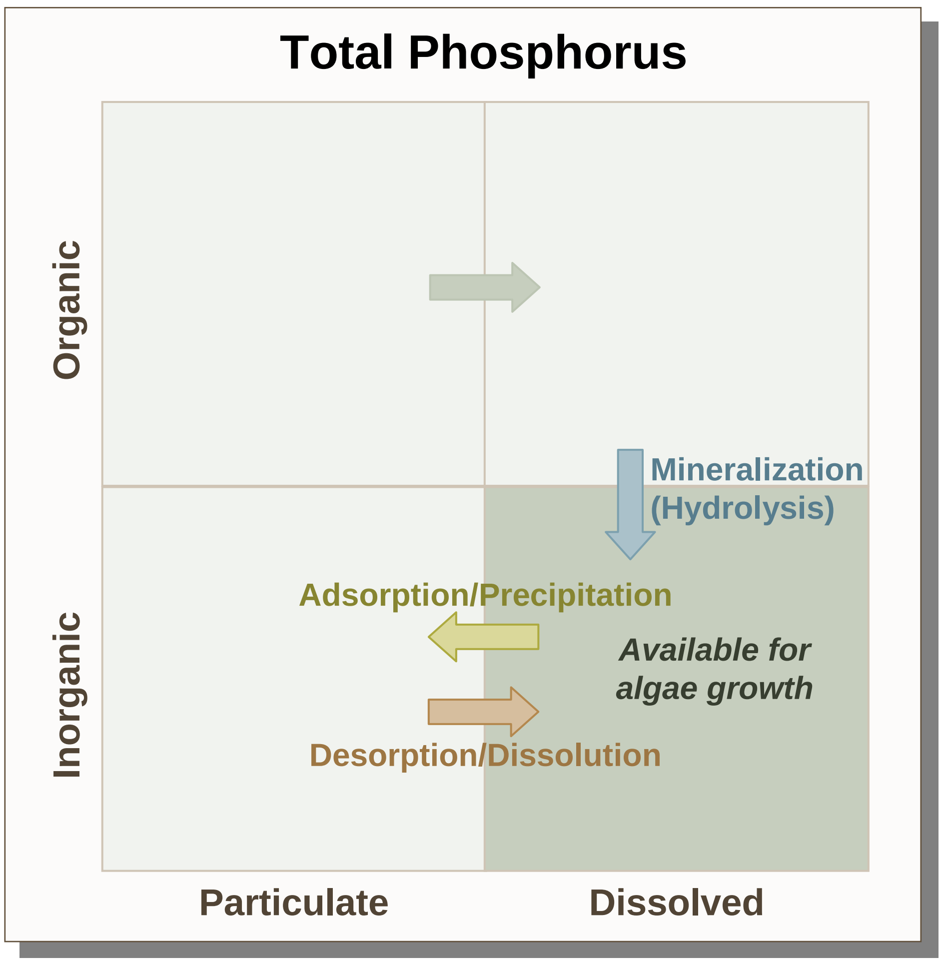

Figure 2-1. Speciation of phosphorus within the environment.

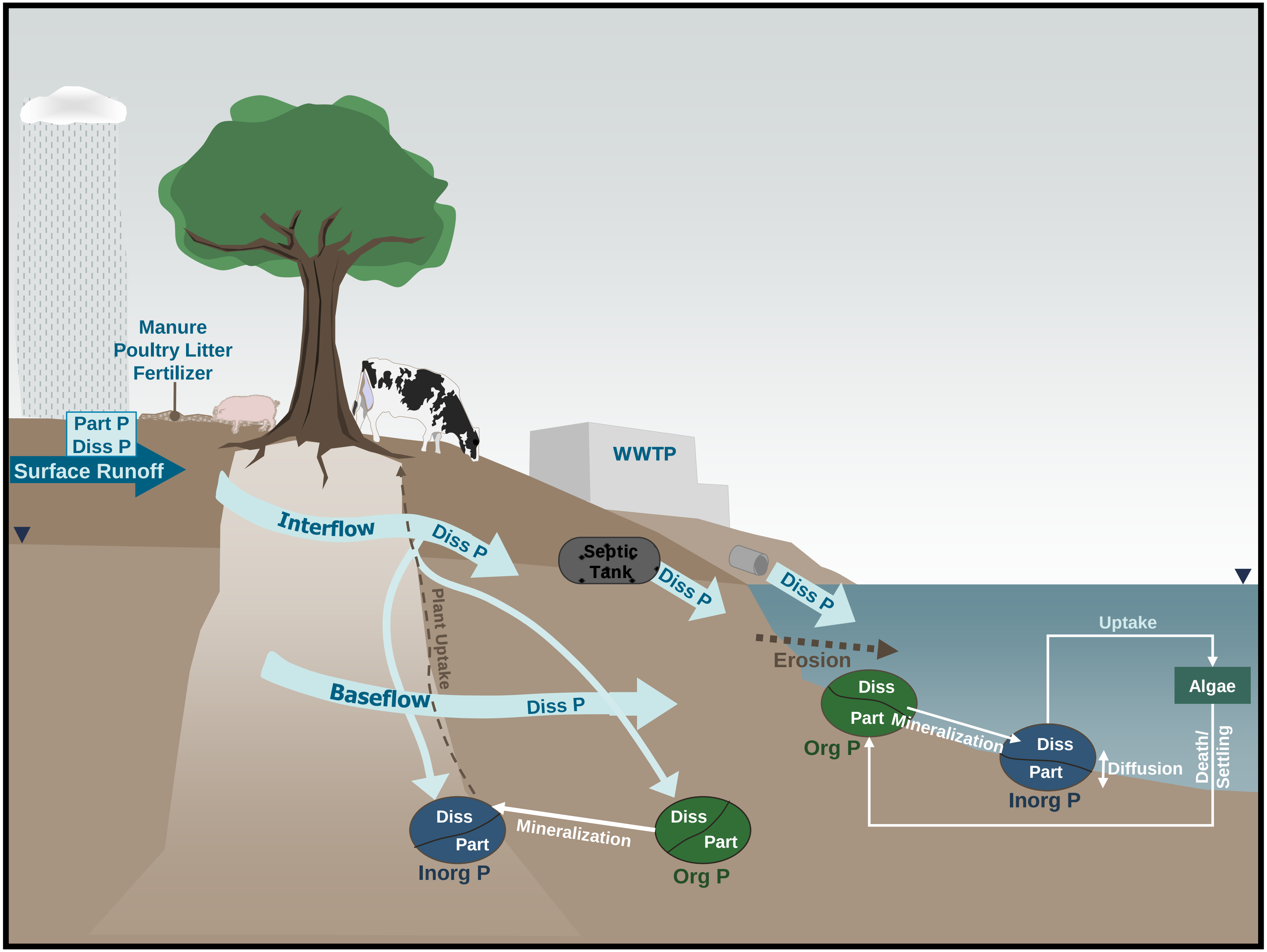

Figure 2-2. Schematic of possible sources of phosphorus to the Illinois River Watershed waters.

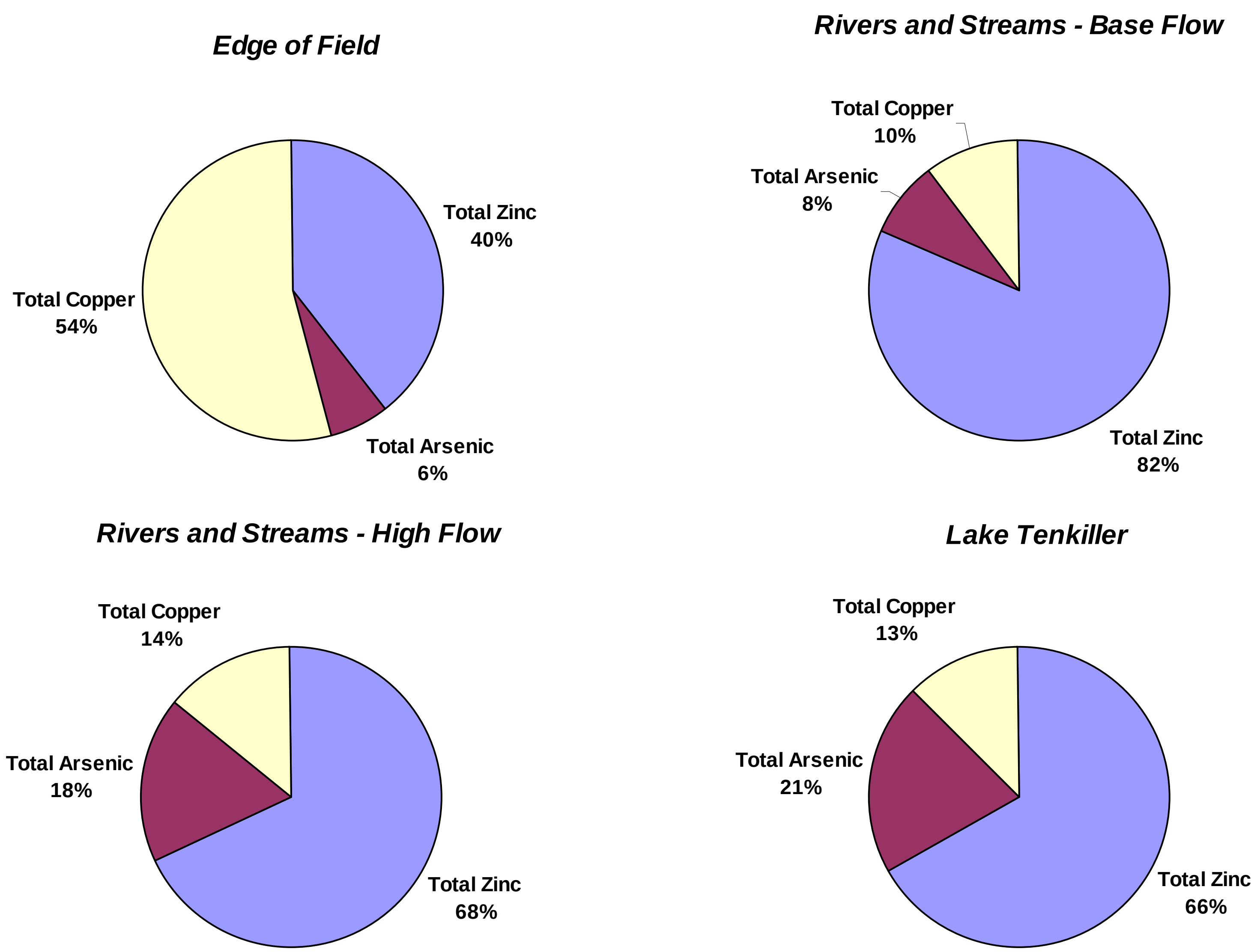

Figure 2-3. Relative proportions of metals by mass in several types of Illinois River Watershed surface waters.

Data source was the following studies from the Plaintiff database: Edge of Field, Rivers and Streams, Biological Study, High Flow Study, and Lake Tenkiller.
Results below quantitation limit included at half of the quantitation limit.
All samples analyzed with EPA method SW6020B.

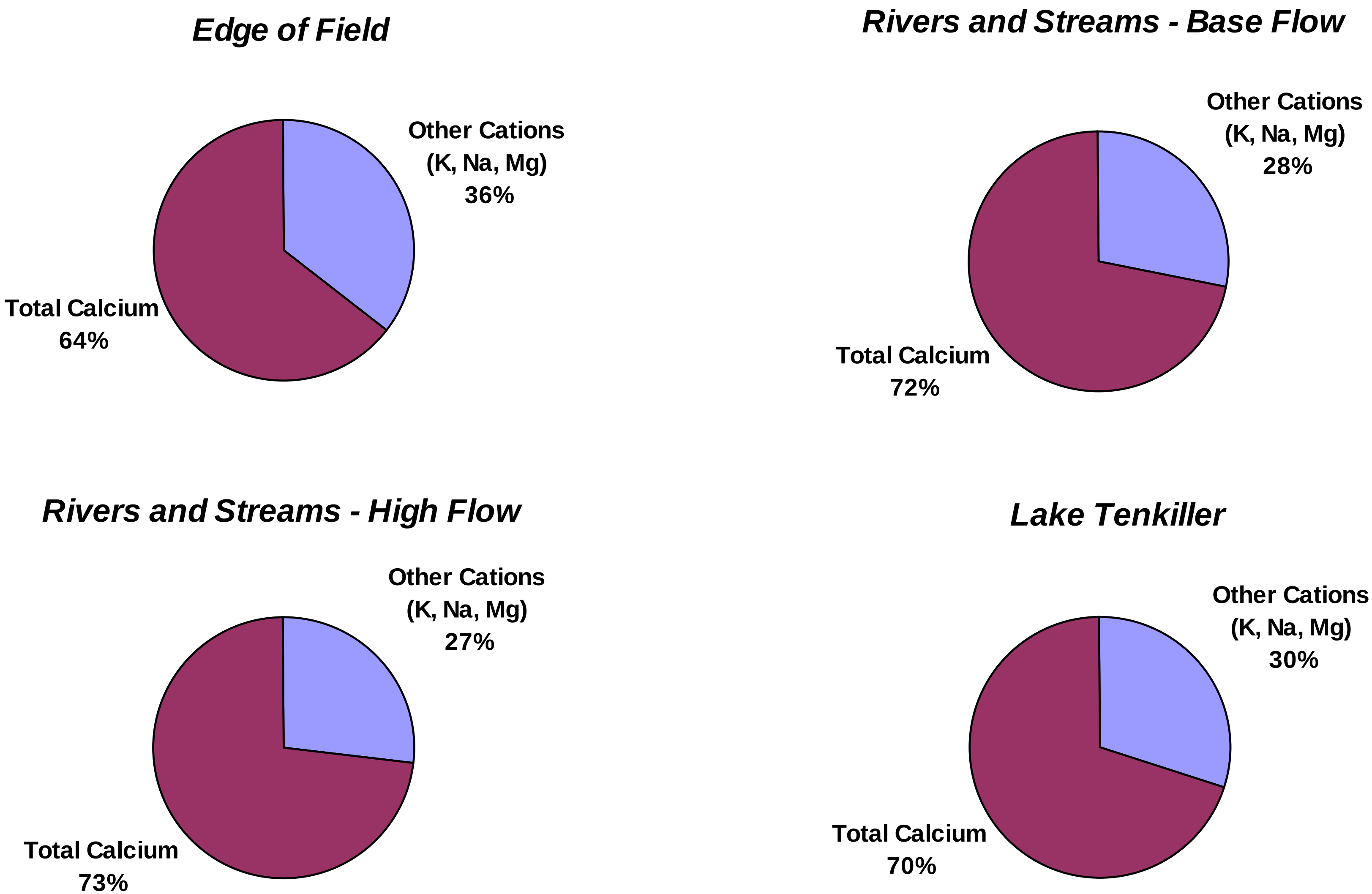

Figure 2-4a. Relative proportions of calcium and other common cations (potassium, sodium and magnesium) by mass in several types of Illinois River Watershed surface waters.

Data source was the following studies from the Plaintiff database: Edge of Field, Rivers and Streams, Biological Study, High Flow Study, and Lake Tenkiller.
Results below quantitation limit included at half of the quantitation limit.
All samples analyzed with EPA method SW6020B. All results are in units of mg/L.

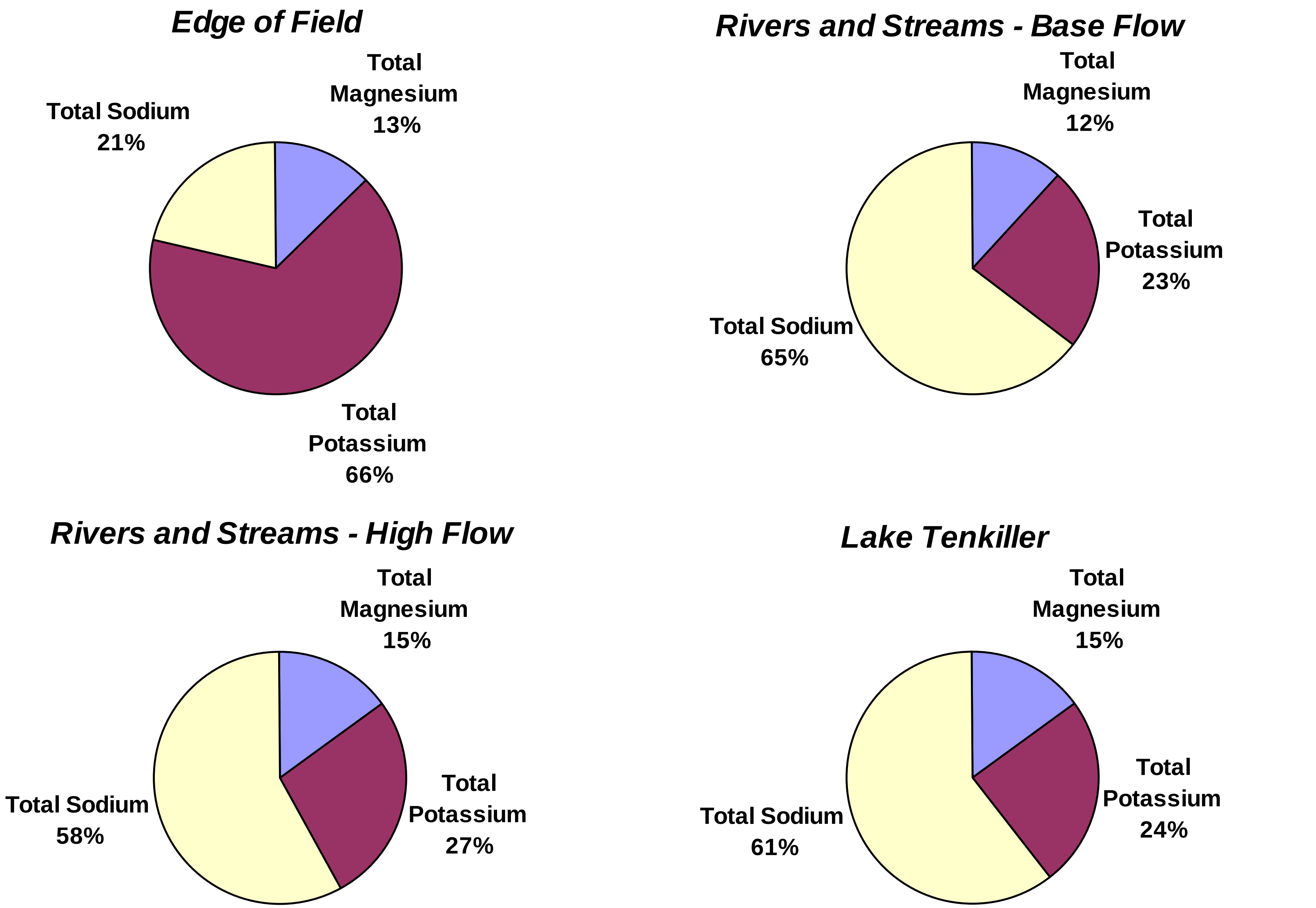

Figure 2-4b. Relative proportions of common cations (excluding calcium) by mass in several types of Illinois River Watershed surface waters.

Data source was the following studies from the Plaintiff database: Edge of Field, Rivers and Streams, Biological Study, High Flow Study, and Lake Tenkiller.
Results below quantitation limit included at half of the quantitation limit.
All samples analyzed with EPA method SW6020B. All results are in units of mg/L.

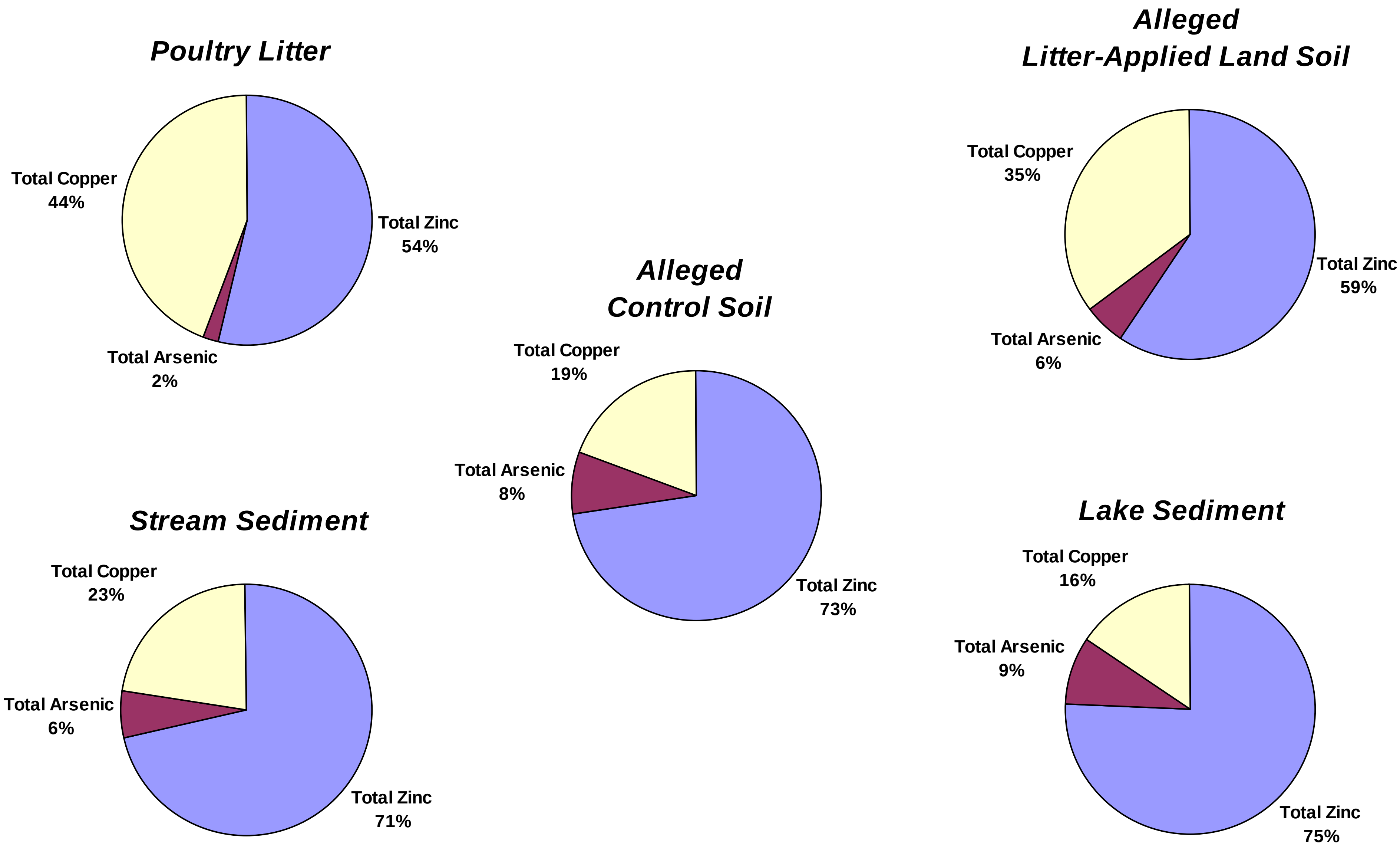

Figure 2-5. Relative proportions of metals in poultry litter, soils and sediments.

Data source was the following studies from the Plaintiff database: Soil and Litter, Rivers and Streams, Biological Study, High Flow Study, and Lake Tenkiller.
Results below quantitation limit included at half of the quantitation limit. All samples analyzed with EPA method SW6020B.
Results for sediments and soil averaged over the top 6 in or 16 cm of each core on a depth-weighted basis.
Duplicate samples within each layer averaged before depth-averaging over core.

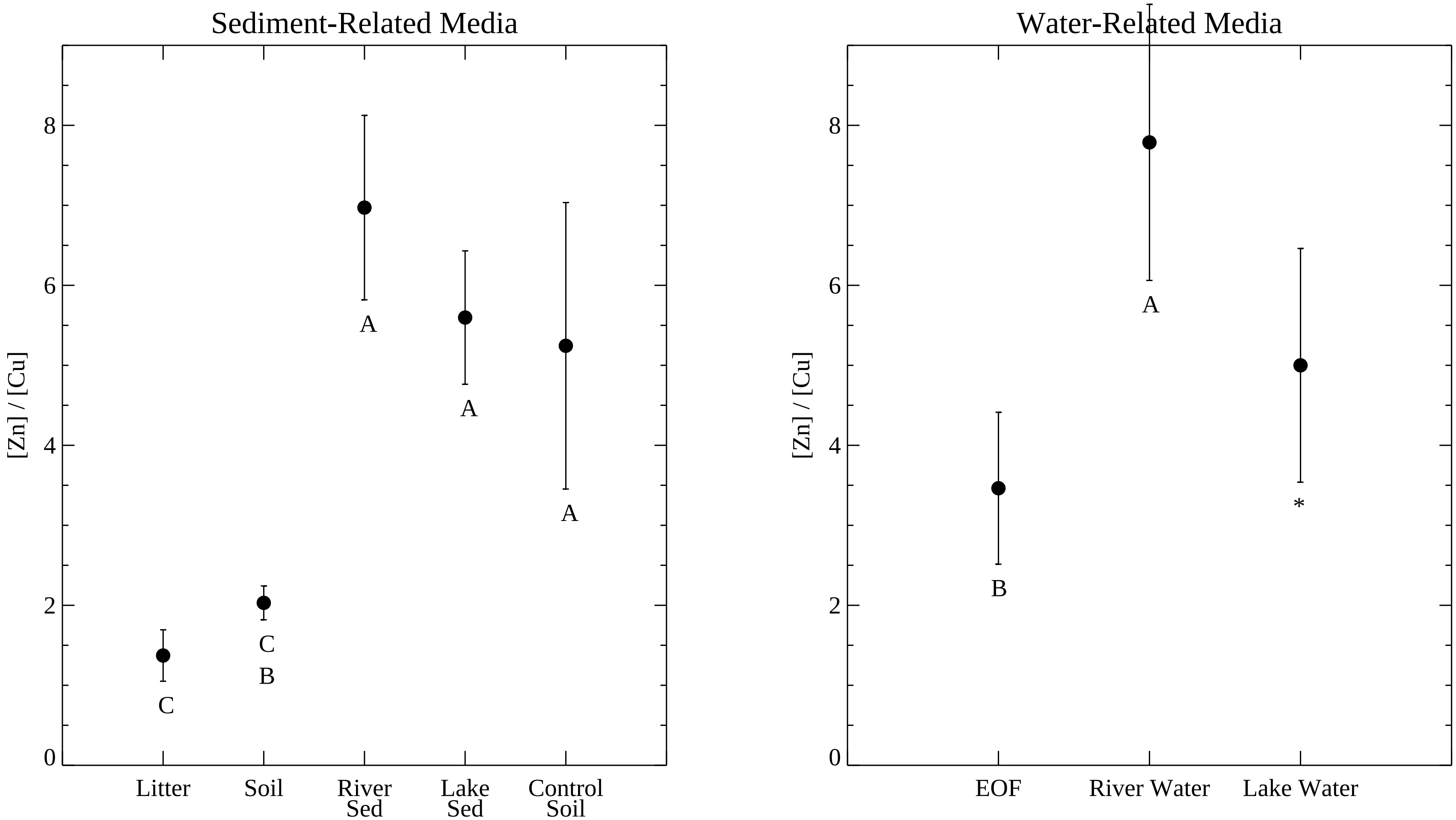

Figure 2-6. Ratios of zinc to copper in the Illinois River Watershed.

Values with different letters are significantly different ($P < 0.05$, Tukey HSD.)
* Zn and Cu levels in lake water were usually below detection limit (only 8% were detectable), therefore lake water was excluded from the statistical analysis.

Data source: Plaintiff data collected 2005-2008. Symbols indicate mean +/- 2 standard errors. Non-detects not included. Only includes samples analyzed with method SW6020B. Results for sediments and soil include top 6 in or 16 cm. Replicate samples at the same depth in each core were averaged, and then samples in each core were length-weighted.

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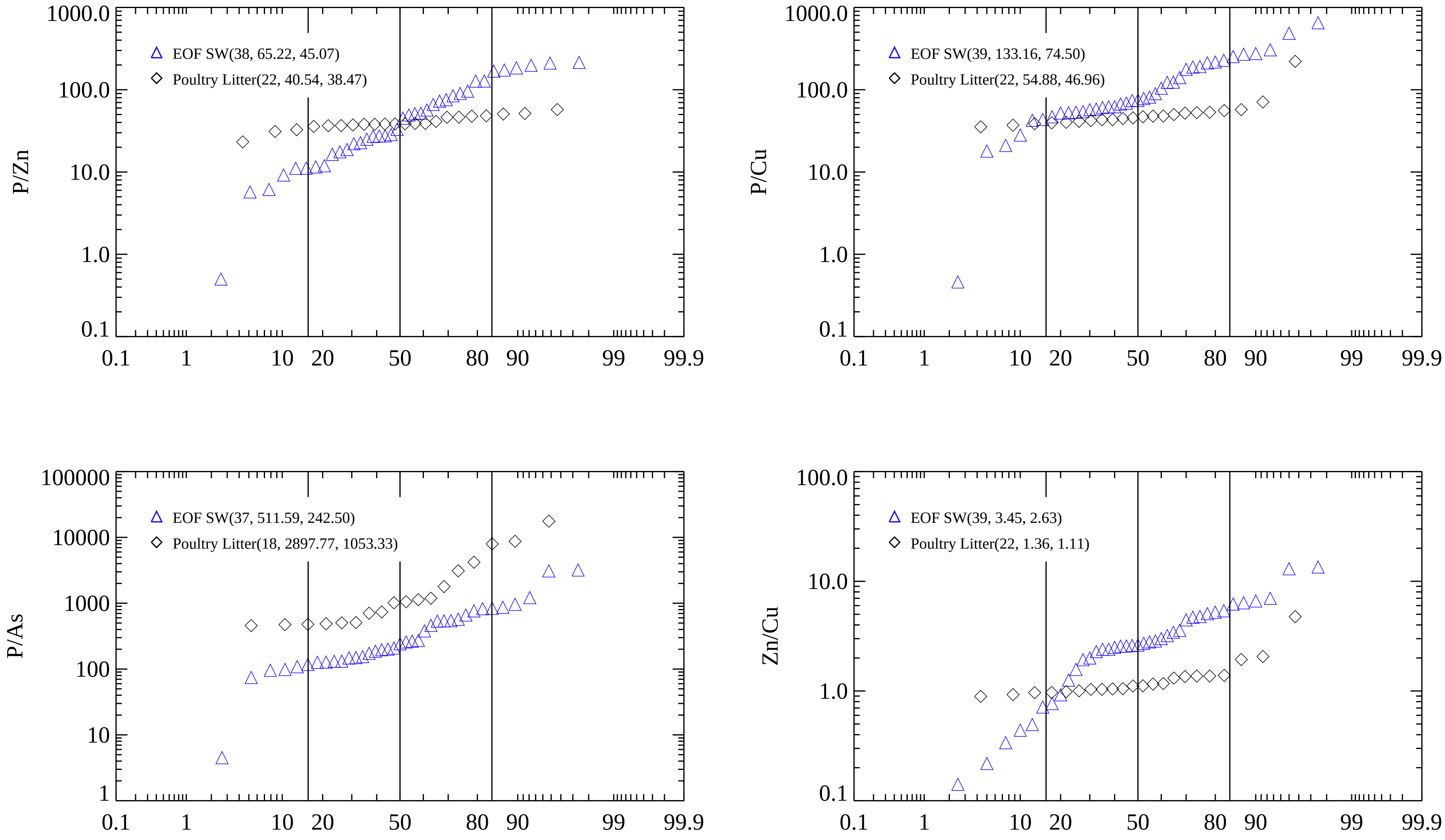

Figure 2-7. Ratios of P/Cu, P/Zn, P/As, and Zn/Cu in EOF runoff and poultry litter.

Data source: Plaintiffs database 2004 - 2008.
Lake sediments, stream sediments, soils are surface data at 0-6 inch or 0 - 16 centimeter.
Non-detects are not included.
EOF concentrations are based on total water concentrations.
Parentheses are ratio count, mean, and median.
Preferred P species analyitical methods from Olsen used, in order: SM18-4500PF, SW6020B and EPA 365.2.
Only includes samples for metals analyzed as Method SW6020B.

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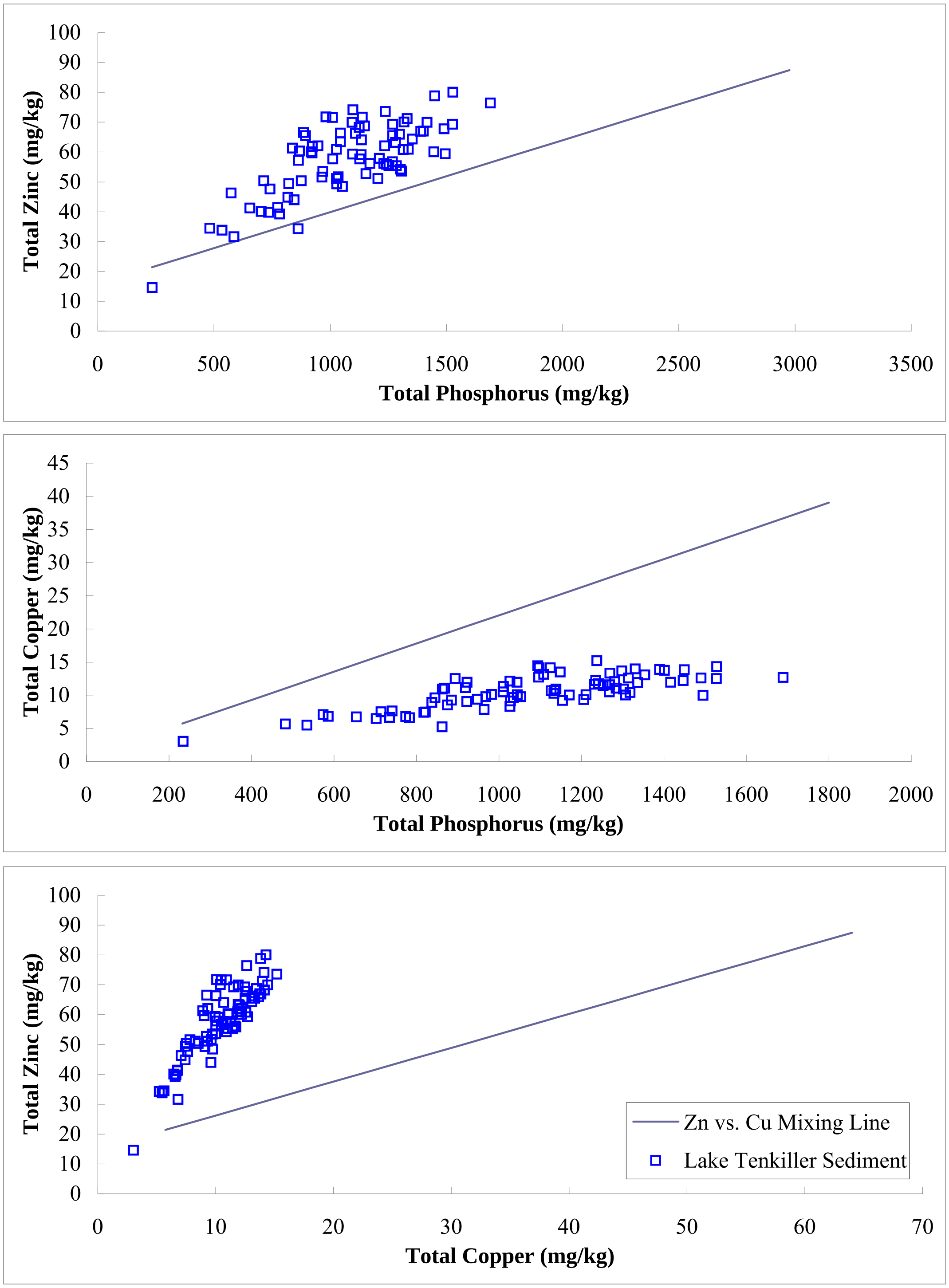

Figure 2-8. Ratios of total phosphorus, zinc, and copper sediments in Lake Tenkiller.

Samples converted to dry weight; Sediments have a core length ≤ 4 cm to exclude composite samples; Samples measured using SW6010B are excluded; Control standards and matrix spike duplicates are excluded; 'Unknown' measurement basis assumed to be wet weight; Sample IDs which do not have all represented analytes are excluded; Mixing line is calculated using a ratio of averages of control soil and poultry litter for each analyte.

Data source: Plaintiff's Database

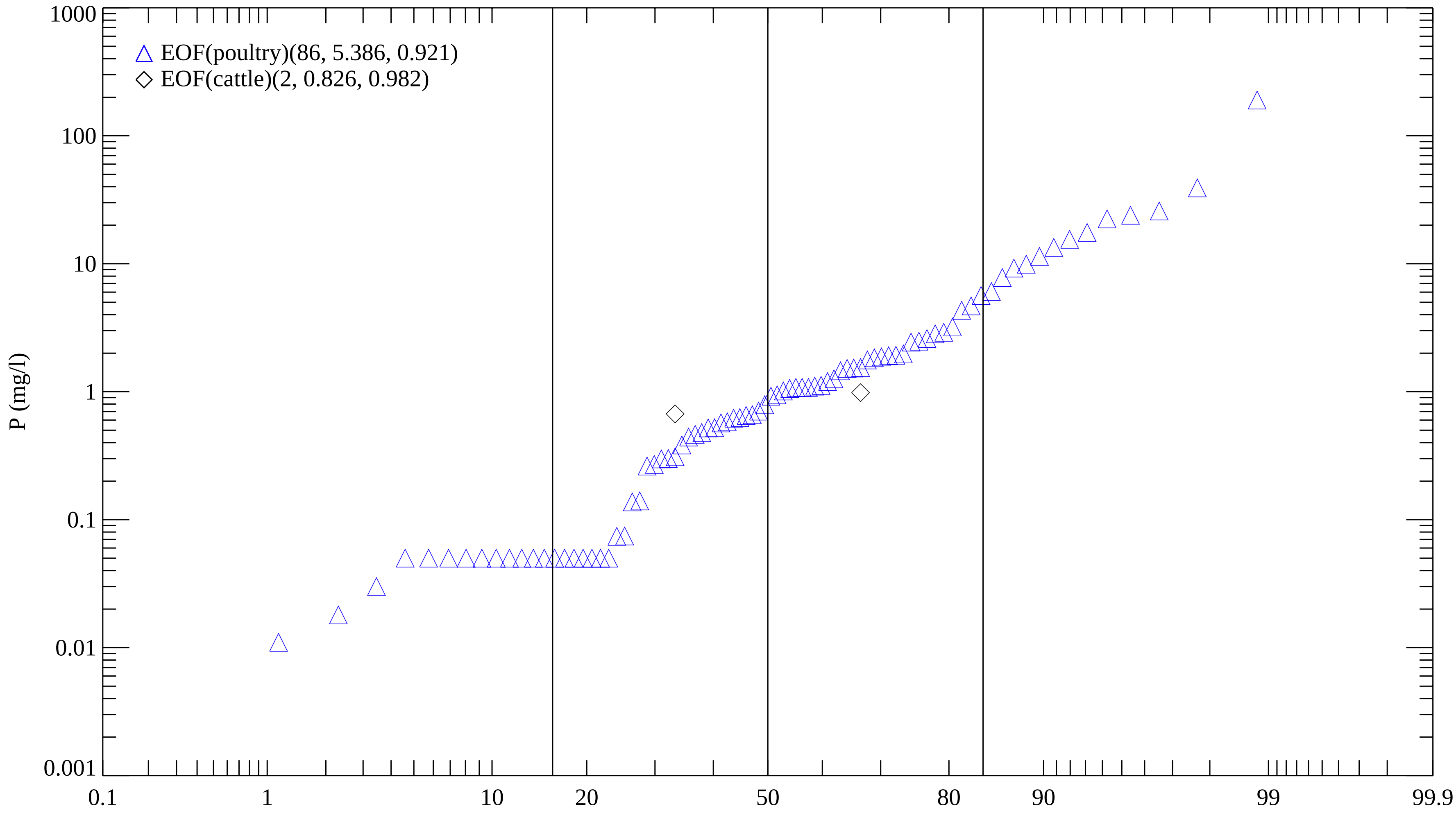

Figure 2-9. Total phosphorus concentrations in EOF (poultry) and EOF (cattle).

Data source: Plaintiffs Database 2004 - 2008.
Non-detects are not included.
EOF concentrations are based on total water concentrations.
Parentheses are sample count, mean, and median.
Preferred P species analyitical methods from Olsen used, in order: SM18-4500PF, SW6020B and EPA 365.2.

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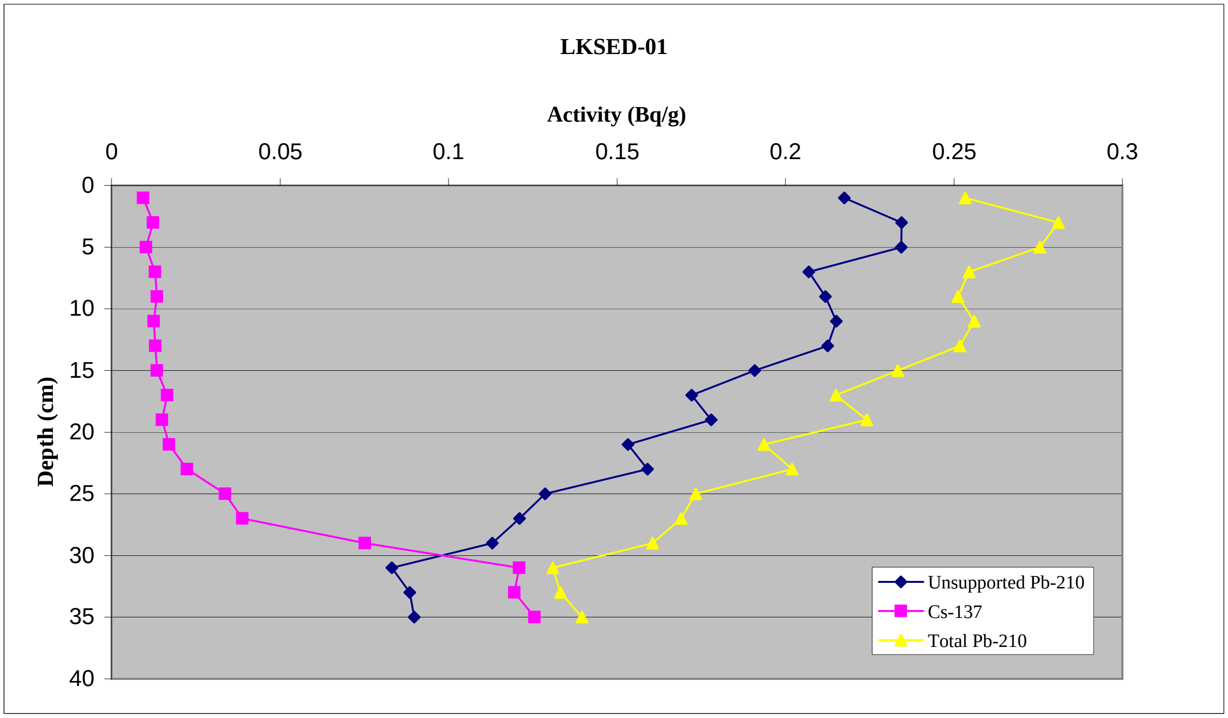


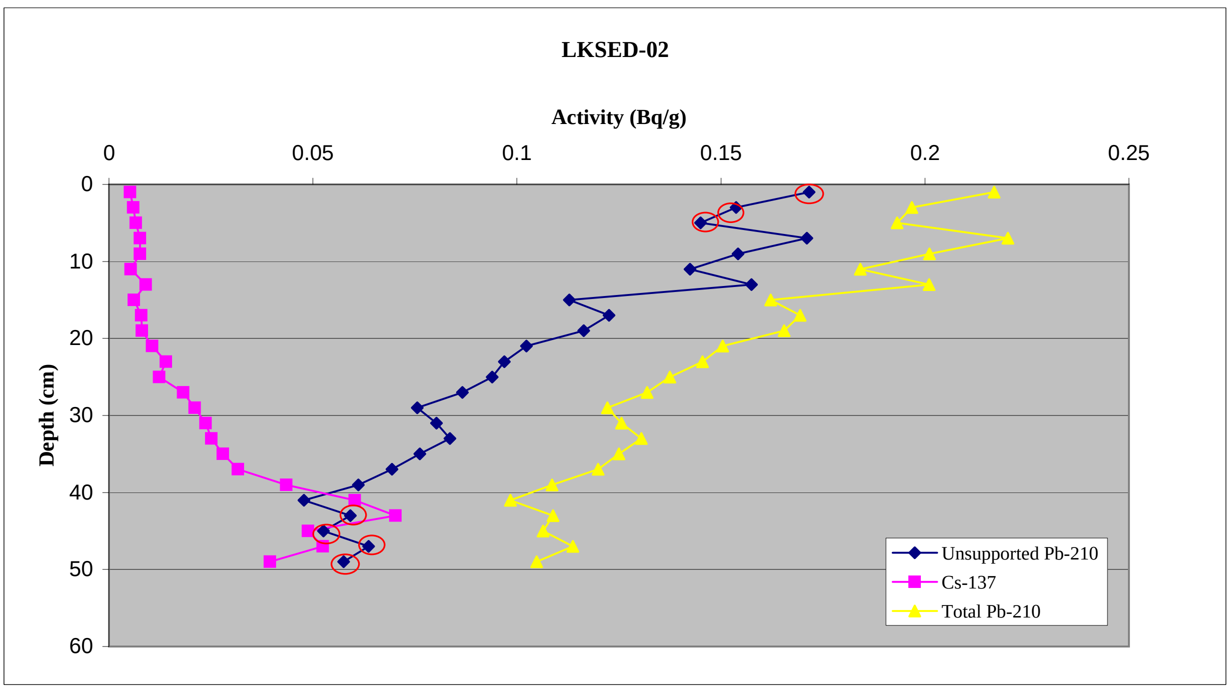
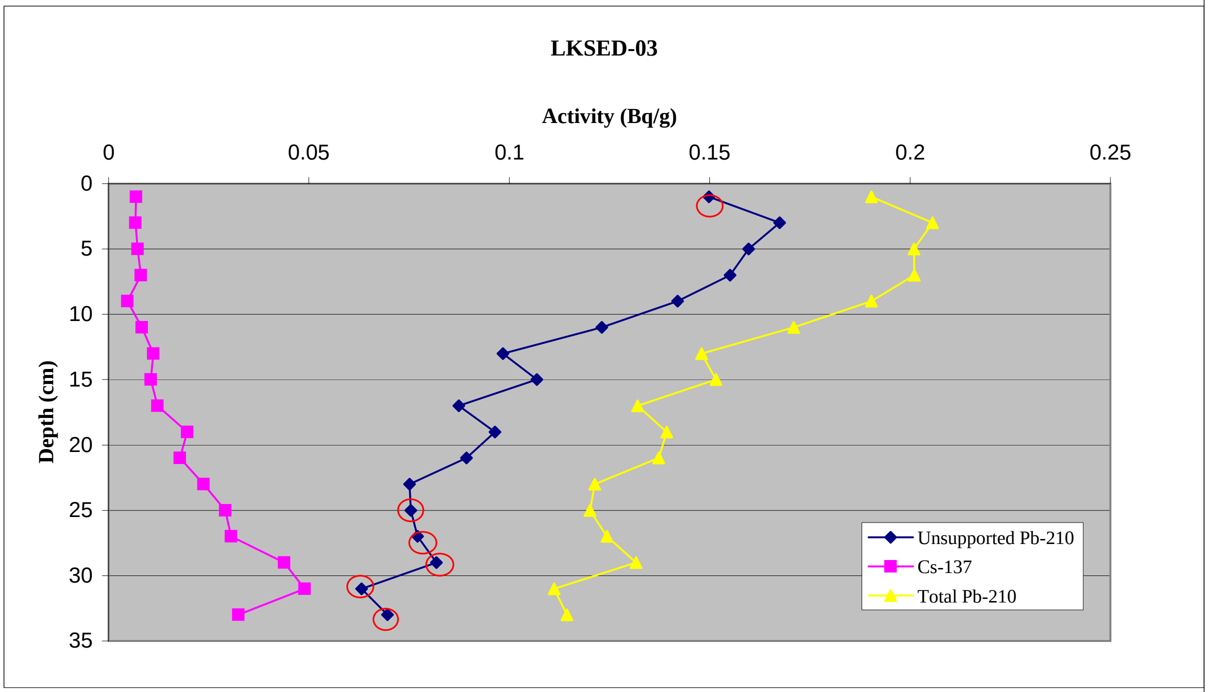


Figure 2-10a. Vertical profiles of ^{210}Pb and ^{137}Cs for Lake Tenkiller Cores.



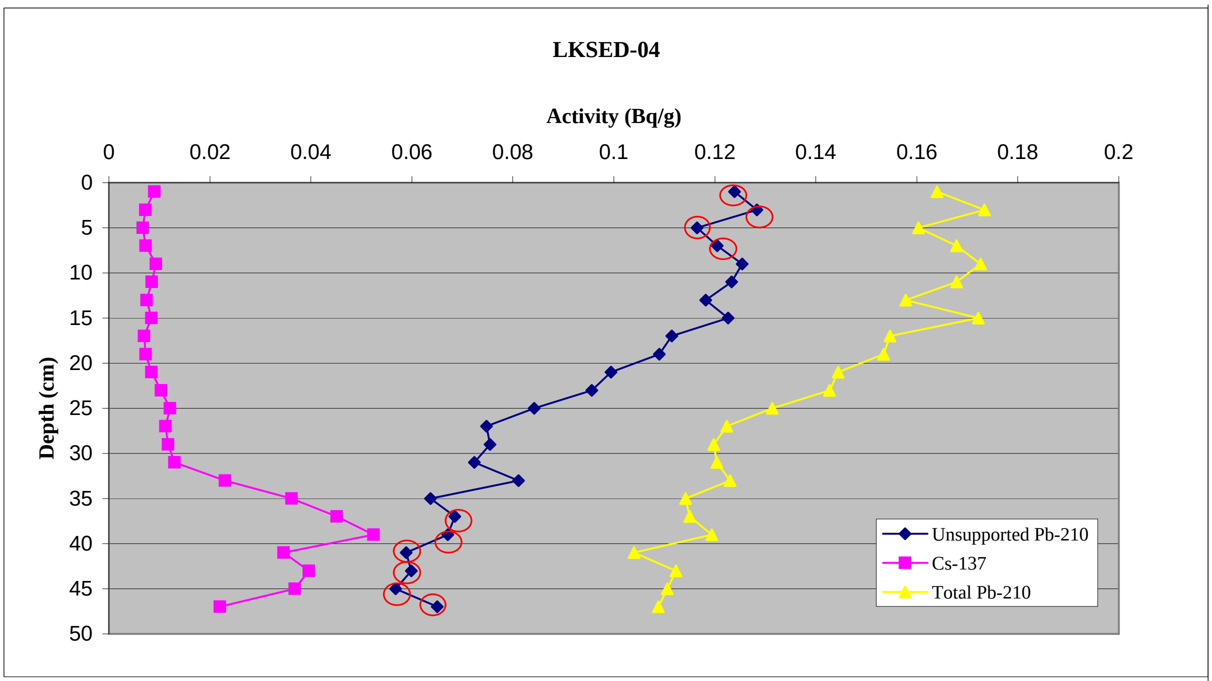
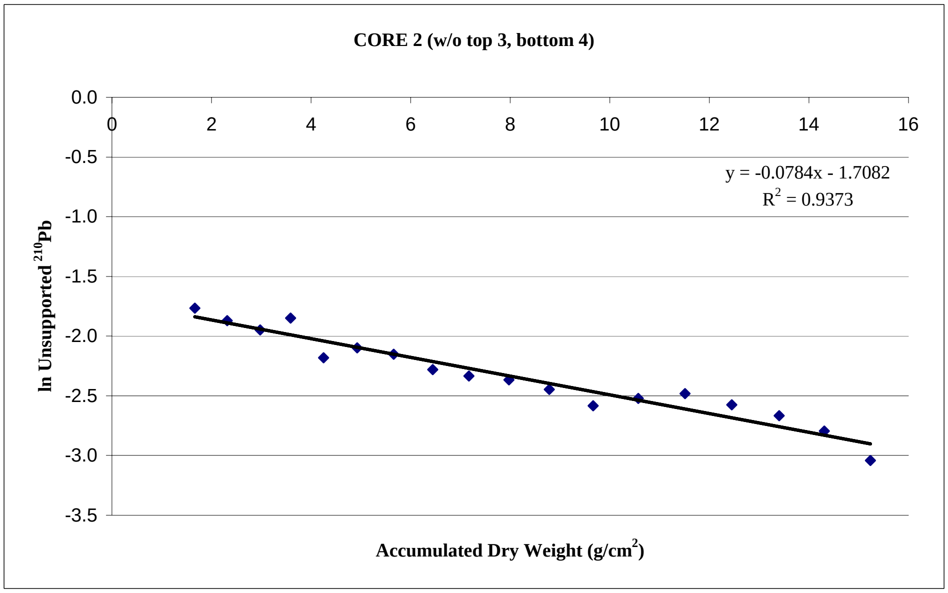
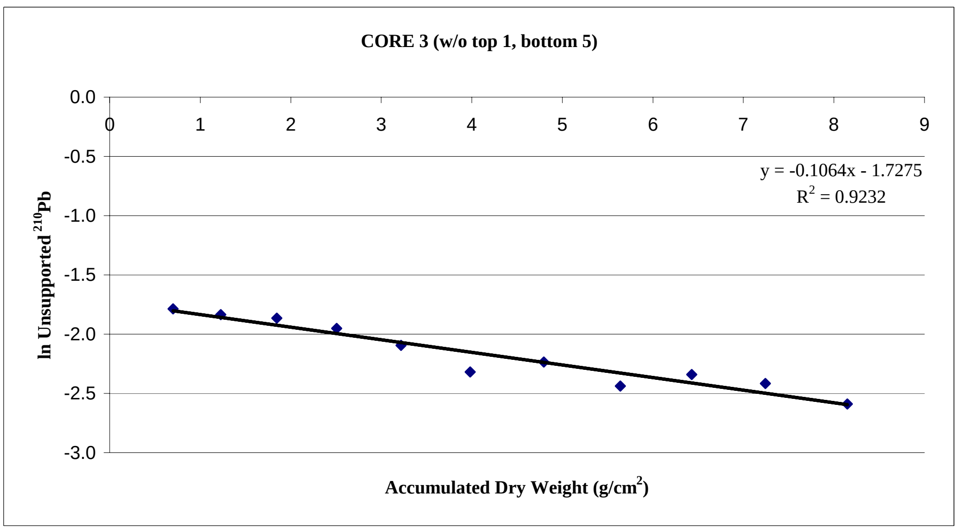


Figure 2-10b. Vertical profiles of ^{210}Pb and ^{137}Cs for Lake Tenkiller Cores.





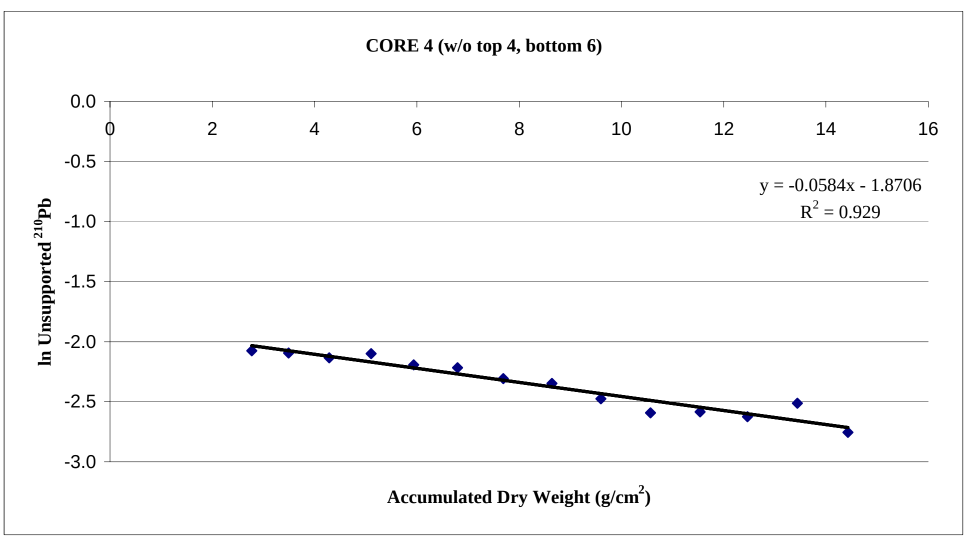


Figure 2-11. Regressions of ^{210}Pb data for Lake Tenkiller cores 2-4.

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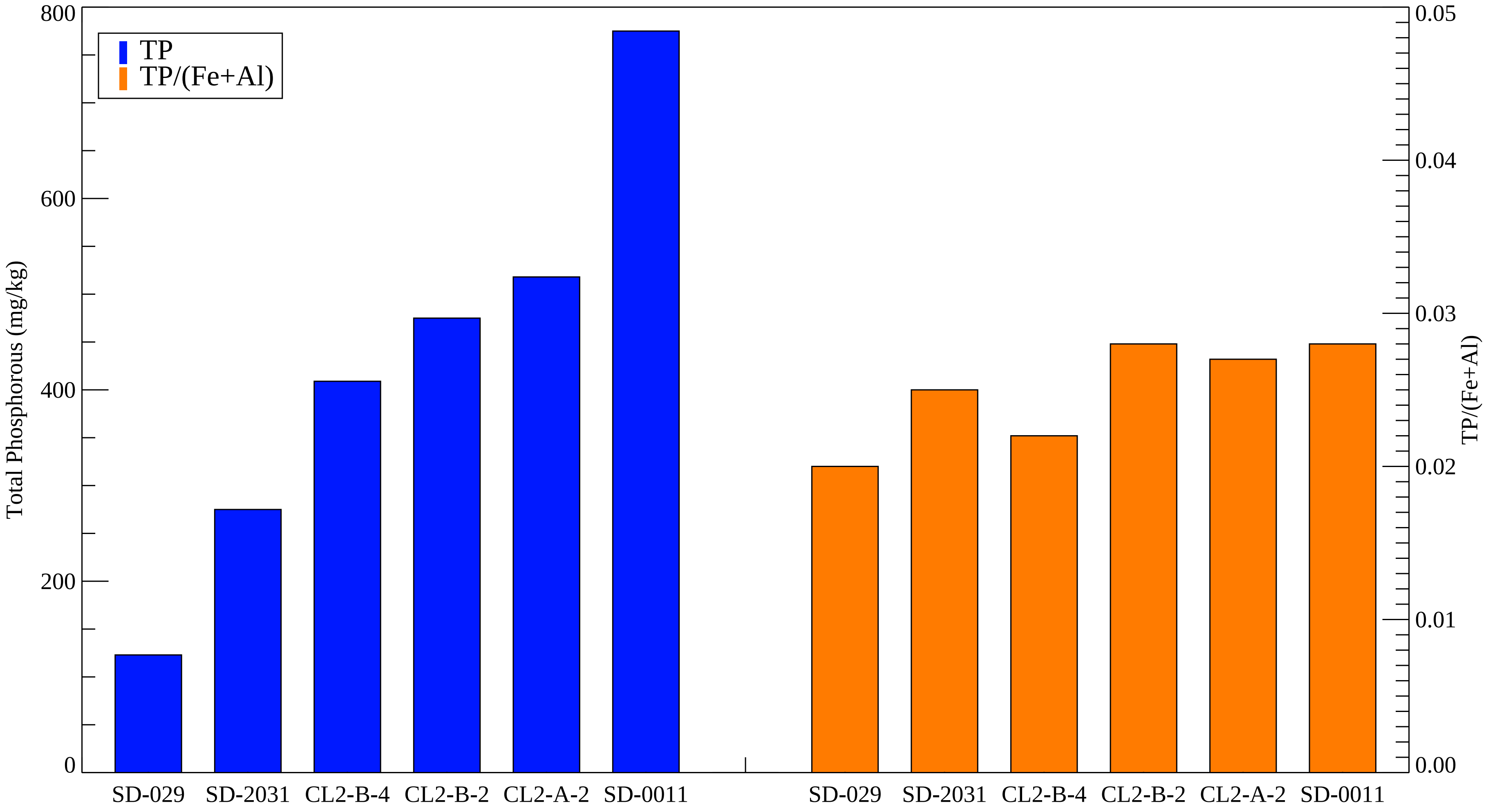

Figure 2-12. Phosphorus, iron, and aluminum content of a few representative stream and control soil samples.
Data: Plaintiffs database.

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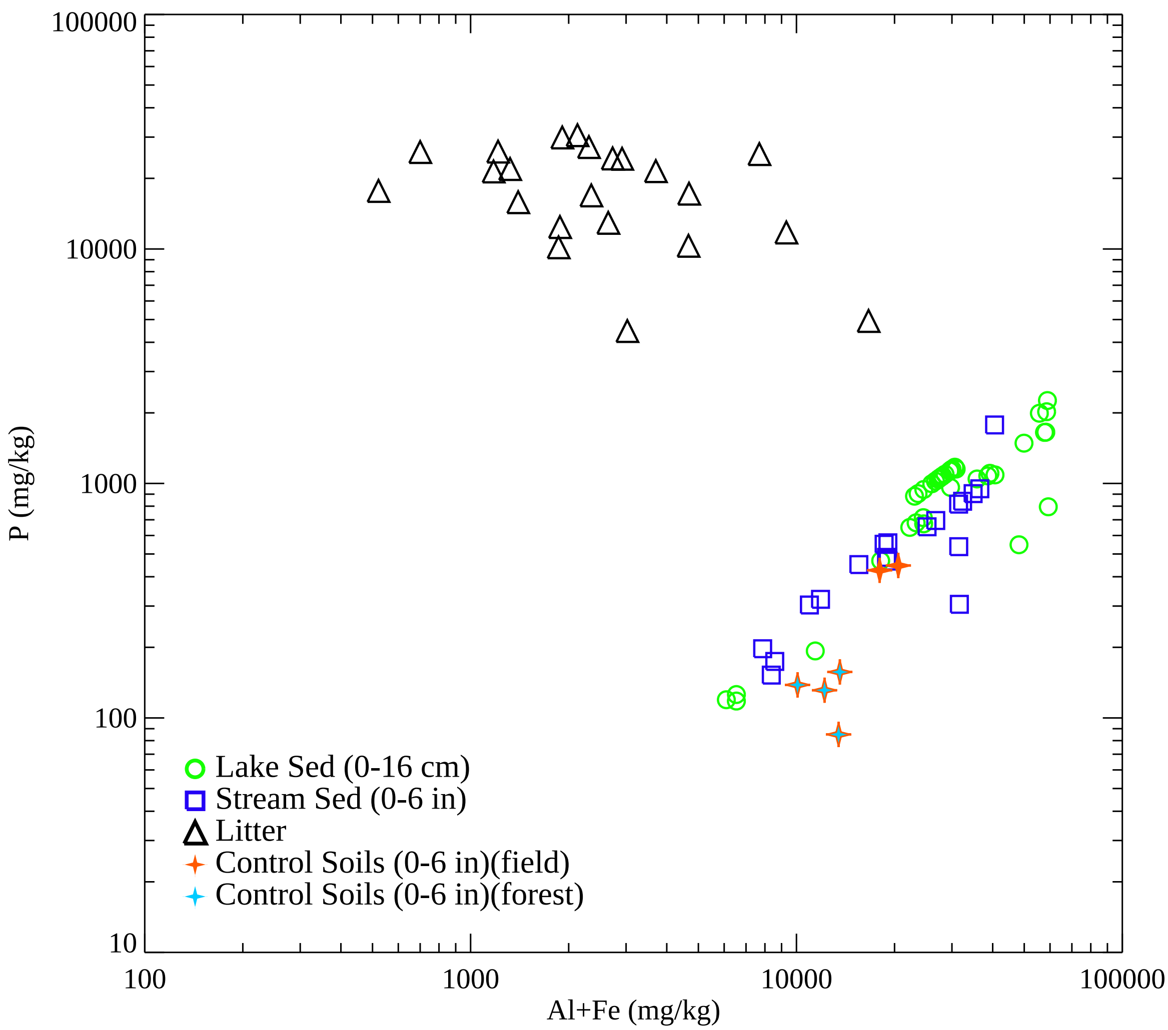

Figure 2-13. Illinois River Project: Cross plot of P vs Al+Fe in different study areas.

Control Soil from the Olsen database.
All solid samples reported on a wet-weighted basis have been corrected for moisture content.
Replicate samples are averaged.
Preferred P species analyitical methods from Olsen used, in order: SM18-4500PF, SW6020B, and EPA 365.2.
Only includes samples for metals analyzed as Method SW6020B.

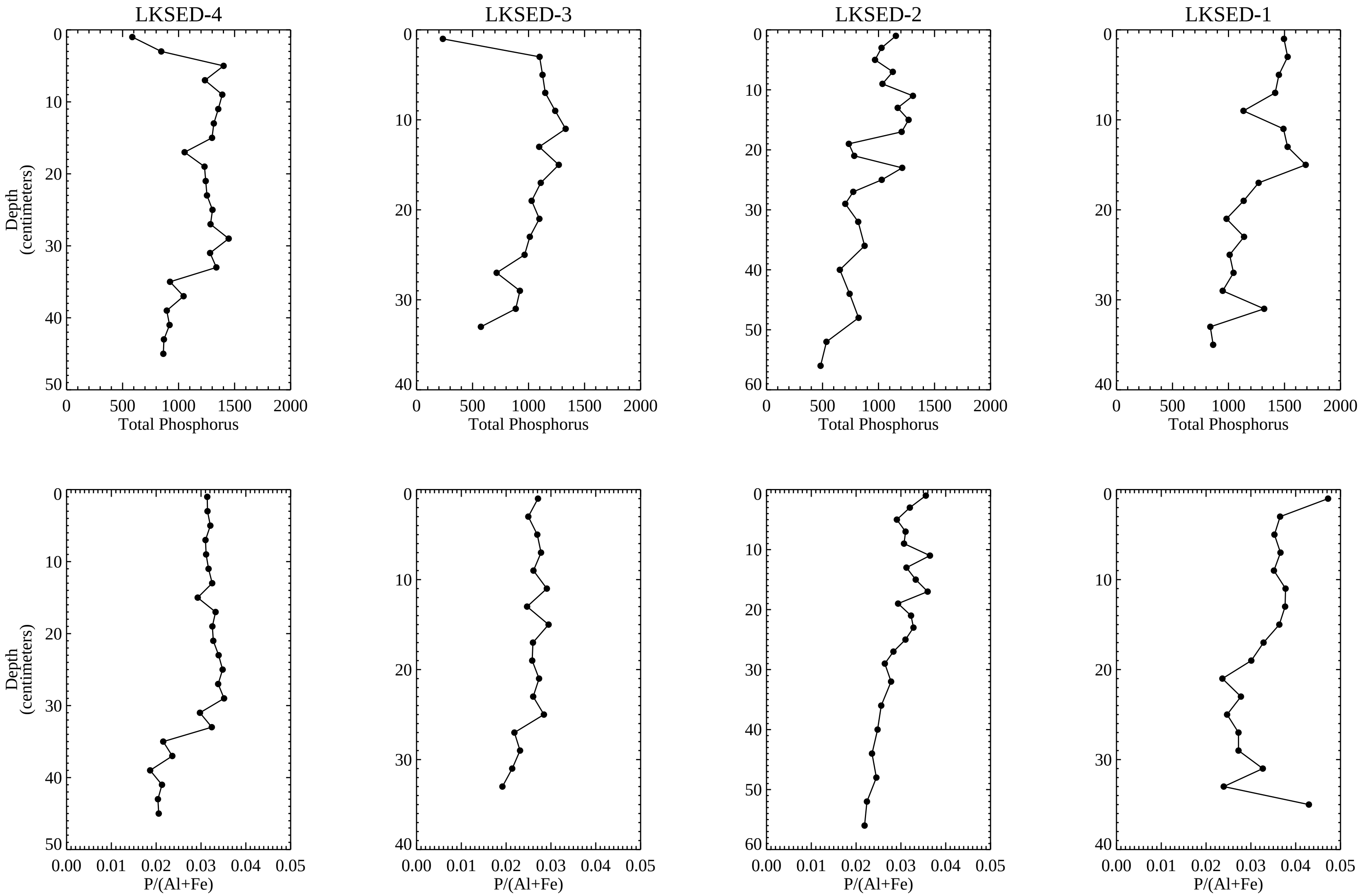

Figure 2-14. Core depth profiles of total phosphorus and total phosphorus normalized by total aluminum + total iron in Lake Tenkiller.

Samples converted to dry weight; sediments have a core length less than or equal to four centimeters to exclude composite samples; core samples are plotted at the midpoint of each segment.

Data source: Plaintiff's Database

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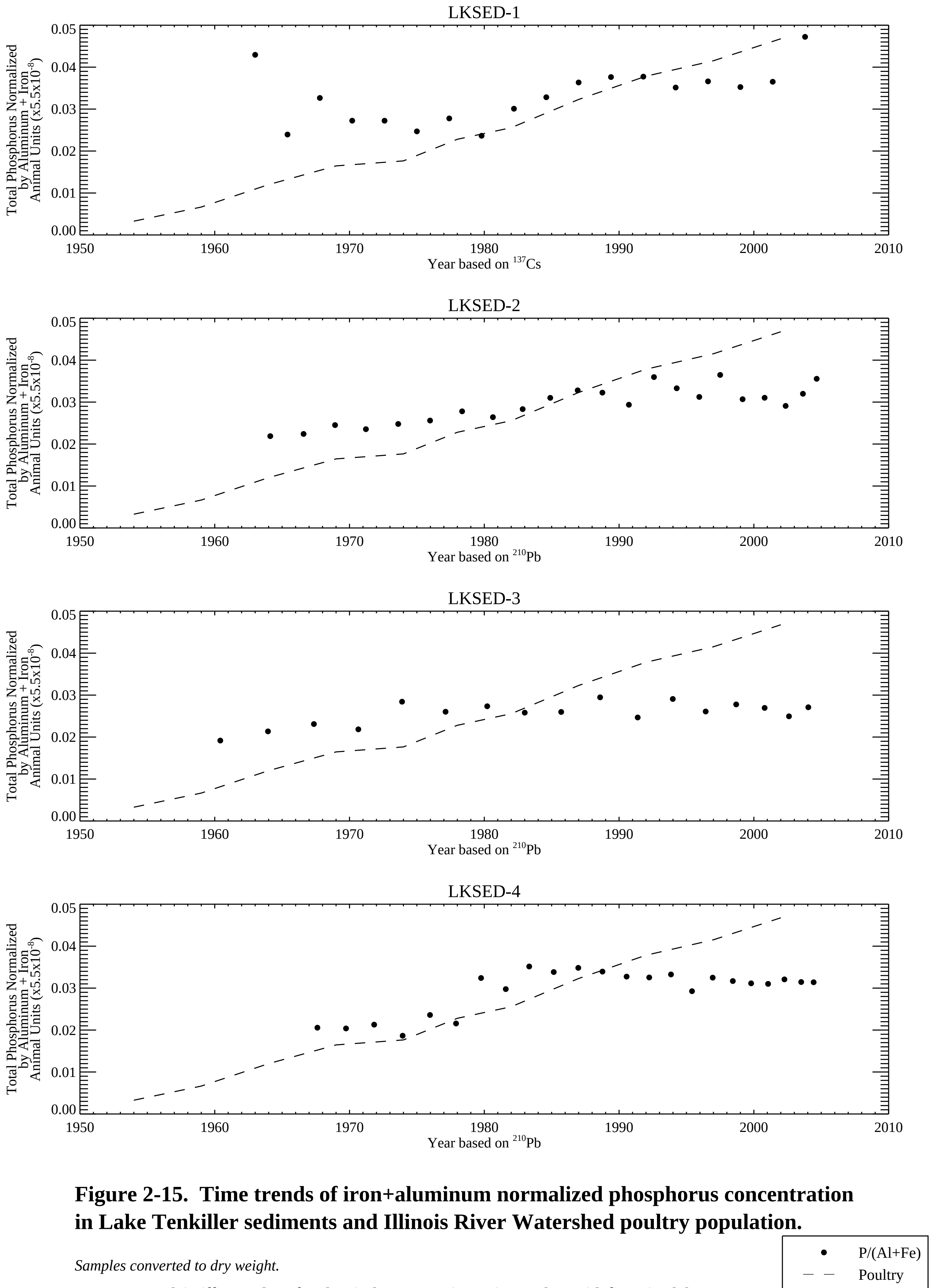

Figure 2-15. Time trends of iron+aluminum normalized phosphorus concentration in Lake Tenkiller sediments and Illinois River Watershed poultry population.

Samples converted to dry weight.

Data source: Plaintiff's Database for chemical concentrations, Figure 3 by Smith for animal data

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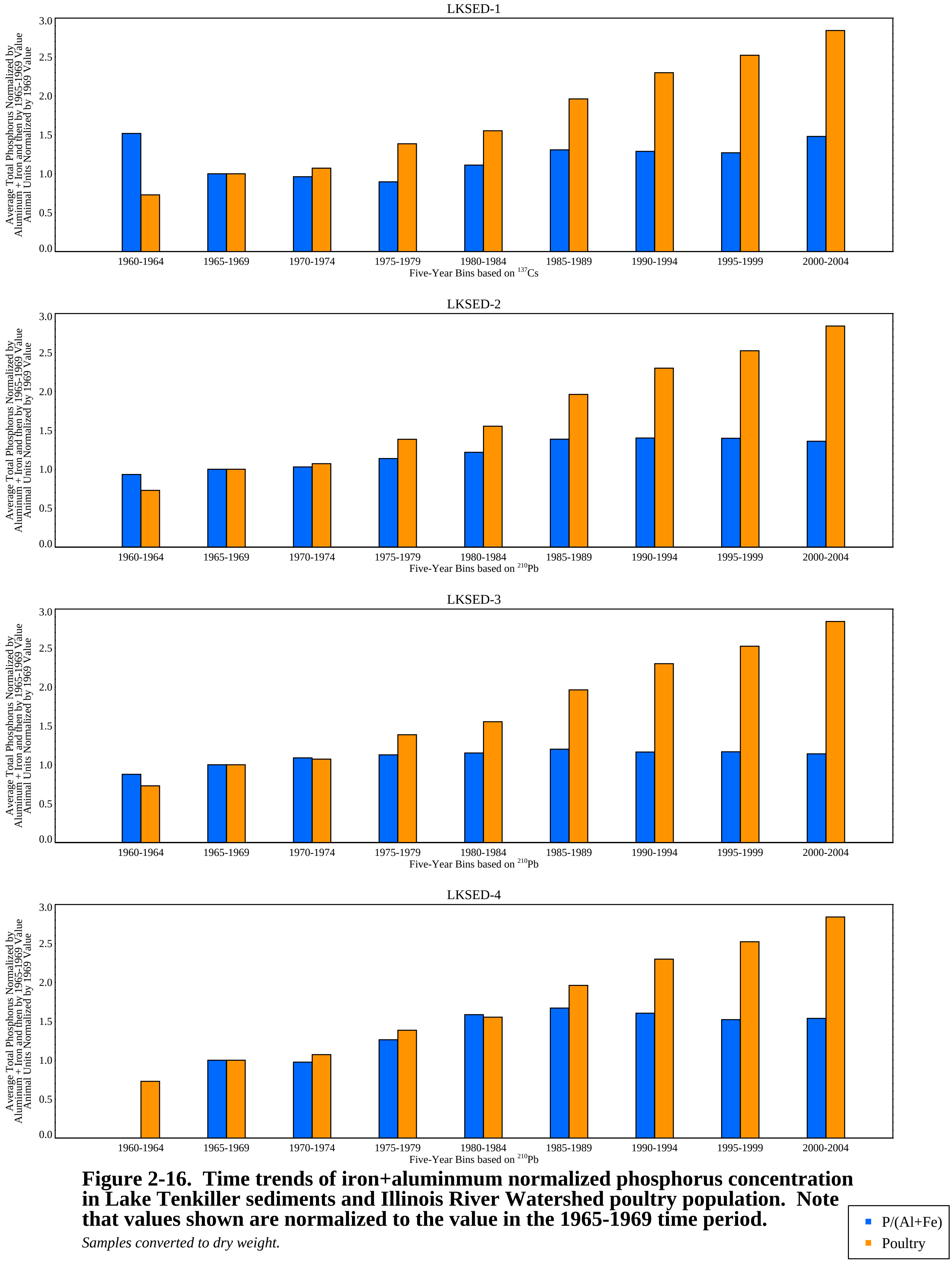

Figure 2-16. Time trends of iron+aluminmum normalized phosphorus concentration in Lake Tenkiller sediments and Illinois River Watershed poultry population. Note that values shown are normalized to the value in the 1965-1969 time period.

Samples converted to dry weight.

Data source: Plaintiff's Database for chemical concentrations, Figure 3 by Smith for animal data

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